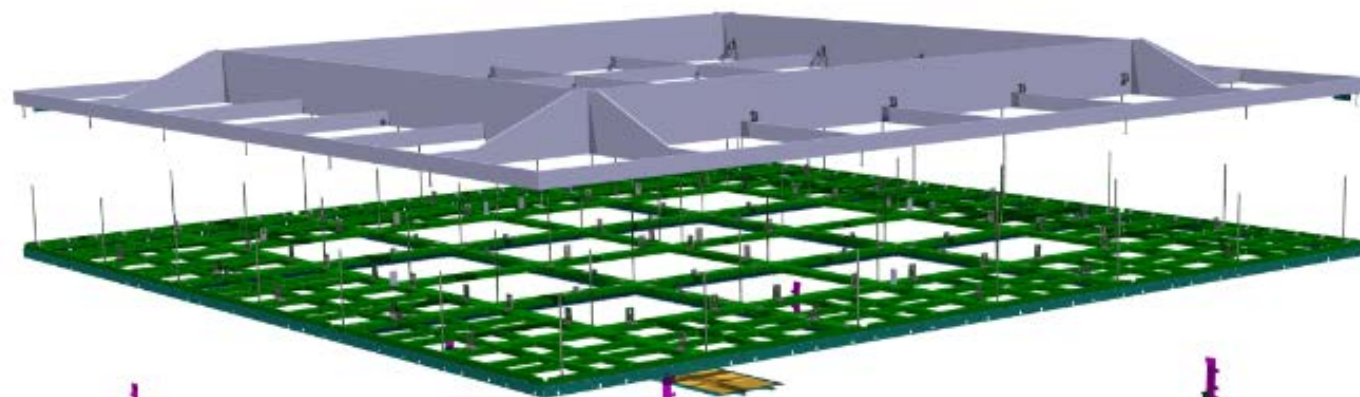


## CRP seconde génération

- Quelques retours sur les aspects techniques des CRPs dans ProtoDUNE-DP
- Point sur les modifications dans le design de la structure mécanique et la grille d'extraction et planning possible
- Point sur les développements des LEMs et anodes pour la 2eme génération
- -Etablir la séquence temporelle des R&D - Tests

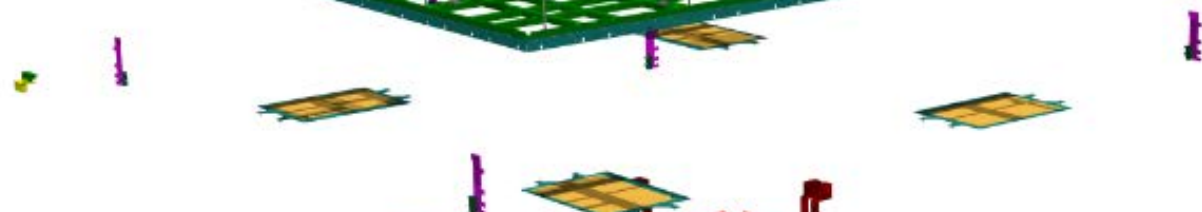
CRP Meeting  
February 13<sup>th</sup>, 2020

# Charge Readout Plane (CRP)

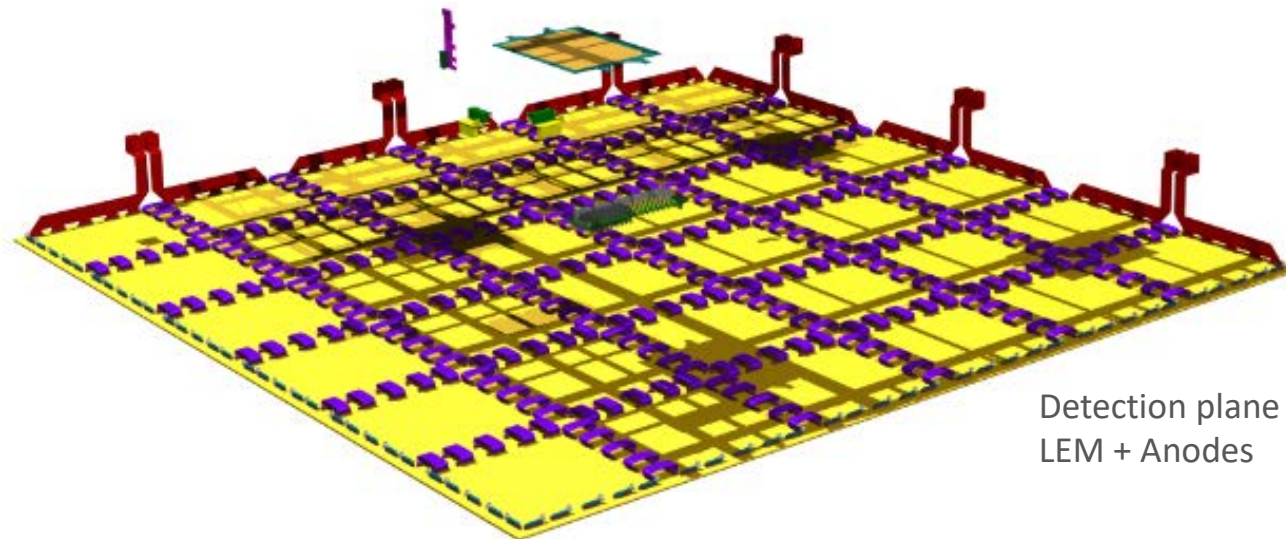


Invar Frame

G10 Frame + Extraction Grid



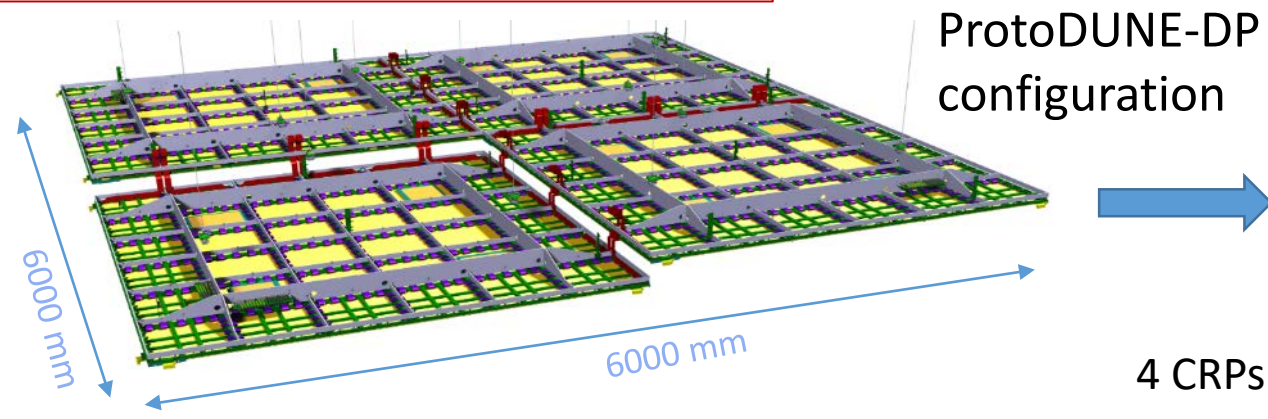
Instrumentation



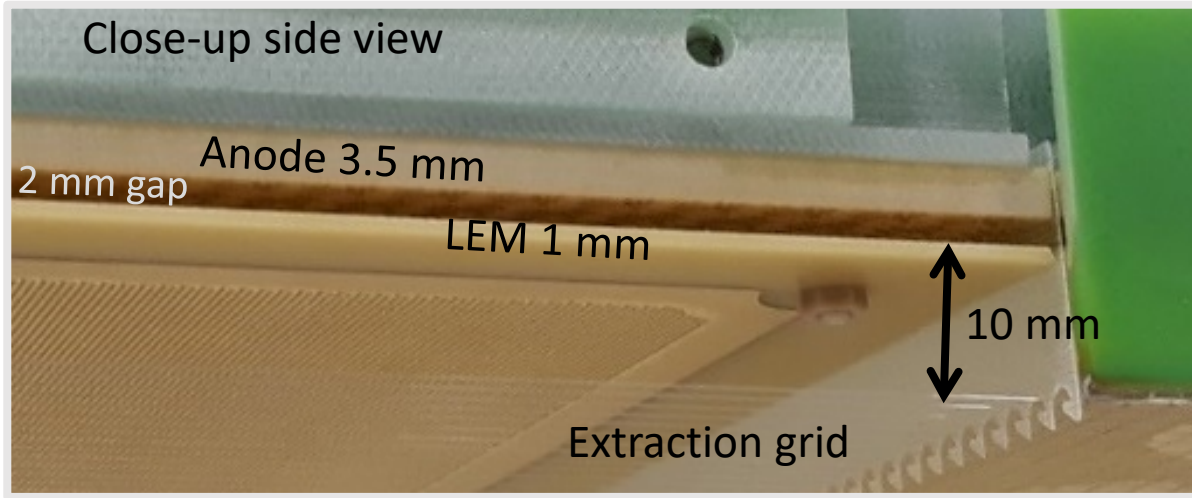
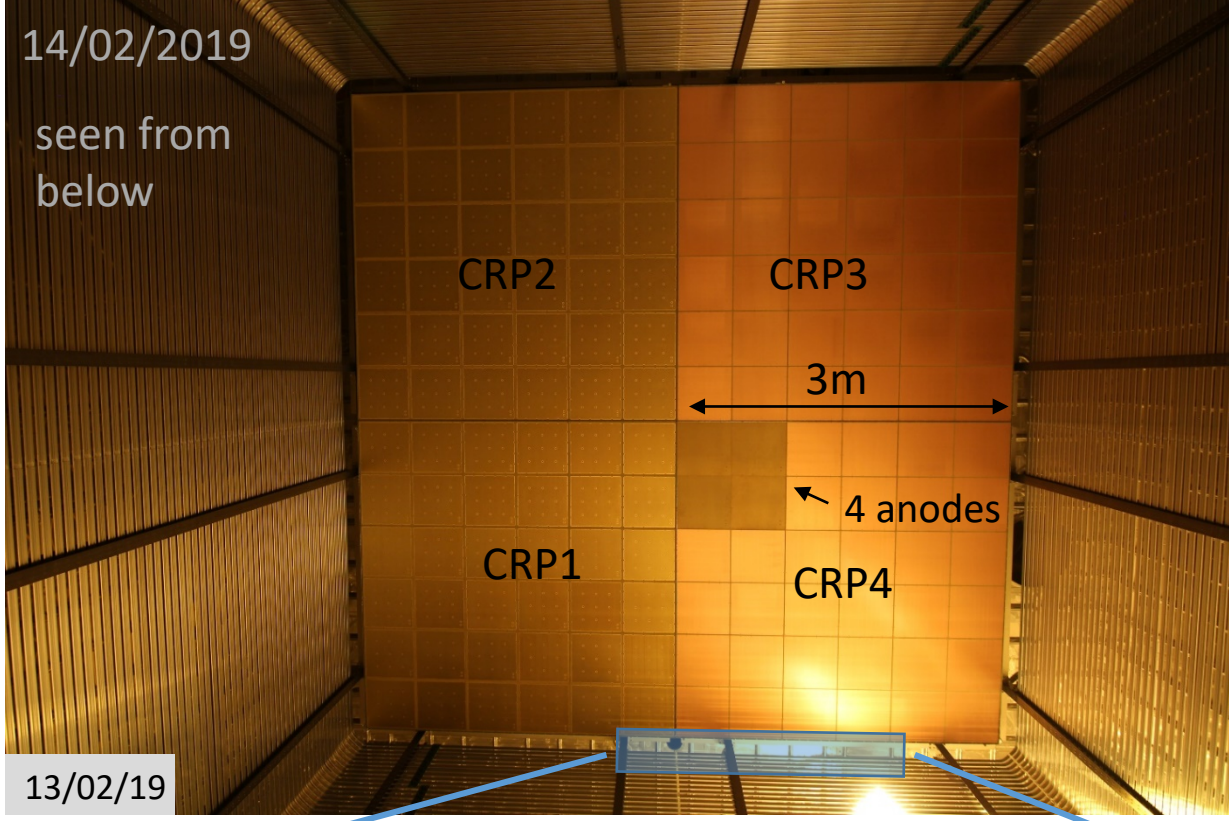
Detection plane  
LEM + Anodes



# Charge Readout Plane (CRP)



- 2 instrumented CRPs with 36 LEMs and 36 anodes (50x50 cm<sup>2</sup>) :
  - ✓ CRP#1 and CRP#2
- 2 CRPs without LEMs:
  - ✓ CRP#3 no anode, CRP#4 has 4 anodes (SP like readout)
- ALL 4 CRPs have a 3x3 m<sup>2</sup> extraction grid



## some feedback from ProtoDUNE-DP construction, tests, installation and operation

- The **construction and installation** didn't present major difficulties nor drawbacks apart:
  - CRP1 first version with grid tension
  - CRP3 broken grid wires after installation
  - Process is understood as well as the schedule and human resources needed
  - However some simplified procedures and systems can be foreseen (ex: transport box, G10 frame....)
  - Decoupling system: finer adjustment and reliability of sliding
- The **cold box tests** were essential in testing LEM and grid HV behaviour and pointing to weak aspects of the CRP grids and HV distribution which were then modified
  - Turn around was very effective but instrumentation was too limited (also HV and Level meter slow control)
  - Surface was probably too perfect compared to the real NP02 cryogenic conditions => need wavy surface?

### Several issues during **commissioning**:

- CRP Planarity is worse than expected at cold (4mm instead of 1.5 mm) => structure has to be revised to be more stiff
- Liquid argon surface instability complicated the operation: new design should integrate several modifications to be less sensitive => larger gap grid-LEM; additional device to get the LAr level at each corner
- Extraction grid and LEM capacitive couplings and stability over time => electrical configuration
- Grid sparking (independently of the mechanism) is harmful to the readout electronics => need to be minimized and controlled => Guard rings to catch the potential sparks
- Charging up of materials or ions may generate electrostatic effects (grid currents) => system to drain the charge?



# Planarity measurement in cryostat

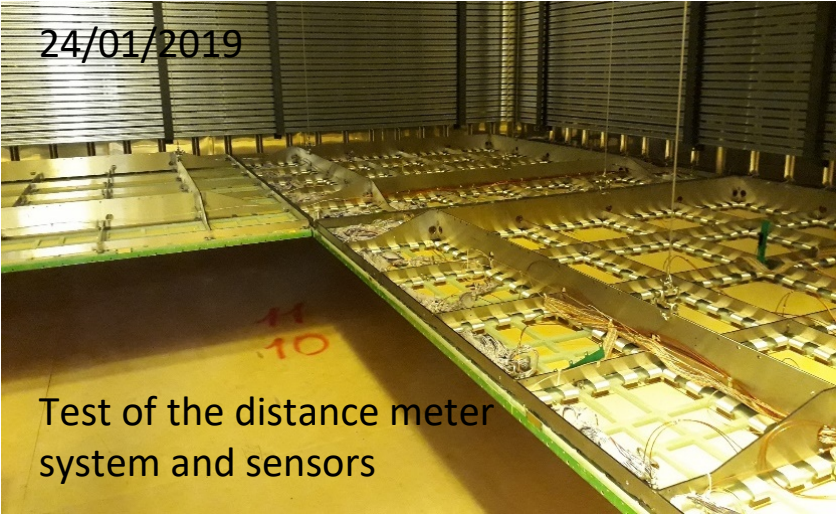
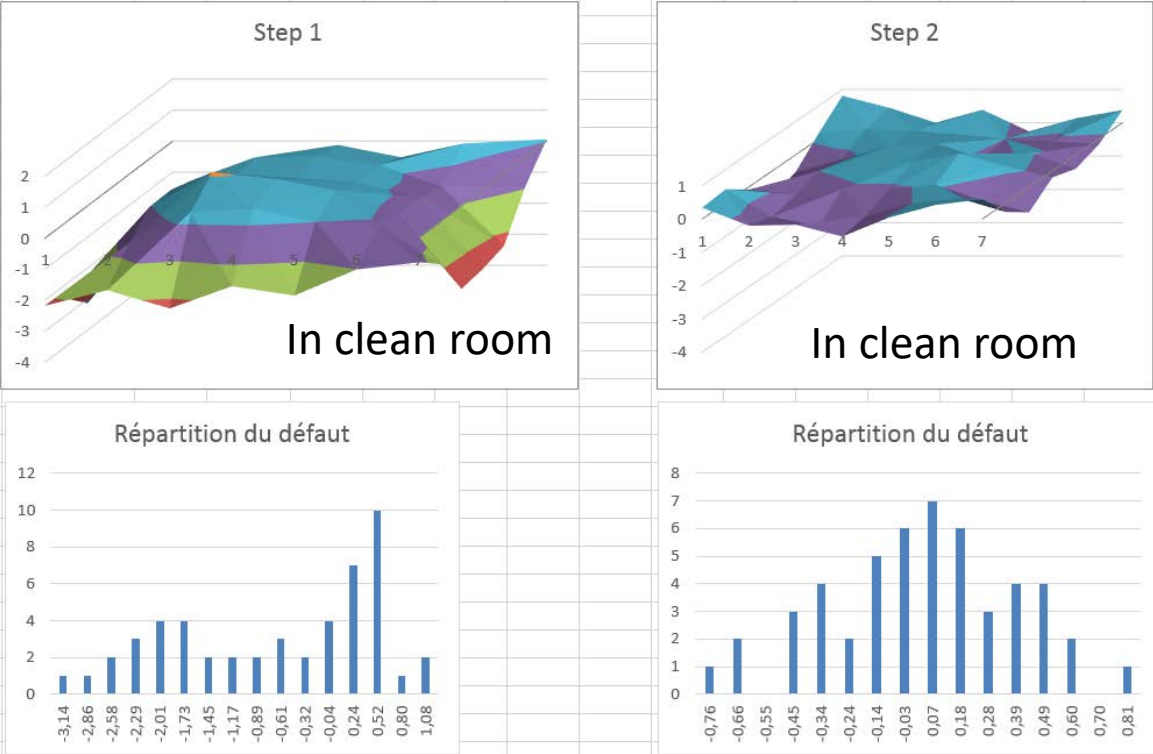


The planarity of the CRP is measured and adjusted on 50 points and 2-3 iterations.

This is performed in one day for a CRP.

There are 2 campaigns of tuning: 1 before the cold box and 1 when inserted in EHN1 cryostat

Example: Planarity distribution for CRP3 :



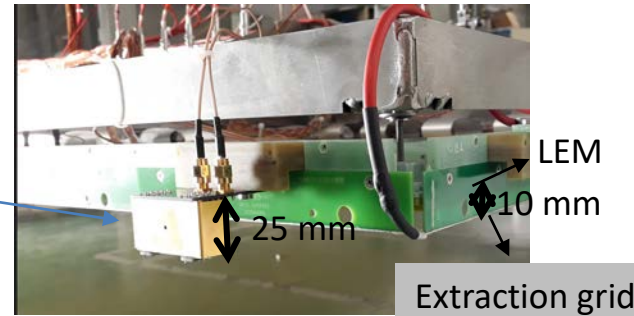
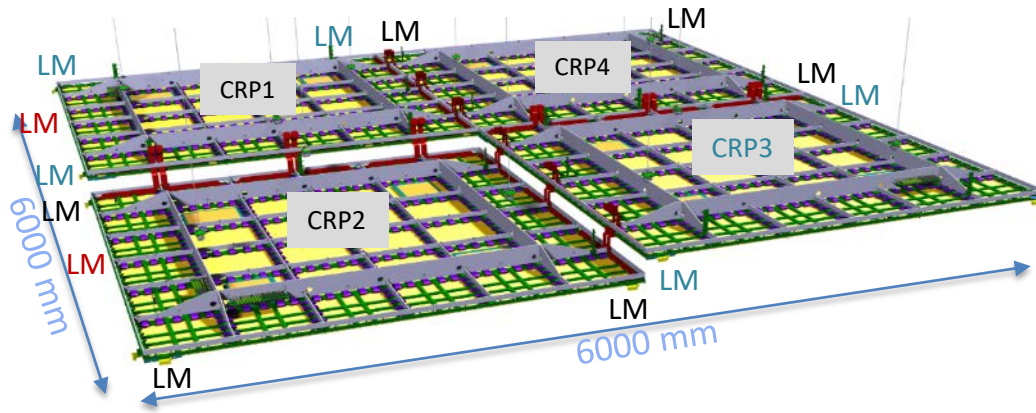
Values in mm	Initial max diff.	Initial std dev	Bdg 185 Max diff	Bldg 185 std dev	Final max diff (mm)	Final Std dev (mm)
CRP1	3,71	1,03	1,53	0,309	0,97	0,240
CRP2	5,95	1,55	1,54	0,363	0,94	0,200
CRP3	4,22	1,192	1,57	0,357	0,73	0,170
CRP4	5,02	1,21	1,16	0,280	0,90	0,240

Planarity over a whole CRP is better than 1 mm.

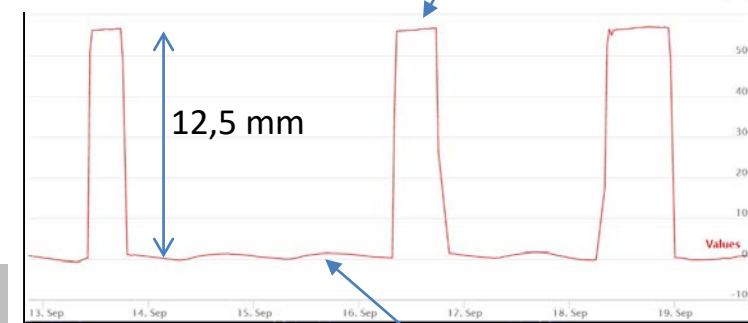


# CRP horizontality adjustments and extraction grid commissioning

## First detector commissioning operation



## Level meter response



capacitive level meter: design 250  $\mu$ m precision

Level meter out of liquid

- CRP1 and CRP2 have 4 level meters: 3 corners + 1 along 1 side
- CRP3 and CRP3 have 3 level meters: 3 corners
- No Level meter in the middle of detection plane

Calibration of the 14 level meters located around the 4 CRPs done in-situ

**Planarity over a whole CRP measured before final installation better than 1 mm**

When the liquid argon reached the level meters the planarity on CRP1 and CRP2 was estimated with **larger spread of  $\pm 2$  mm** which was not foreseen.

Localized effect: **2 opposite corners are lower than the 2 others; shape distortion.**

From mechanical aspects: one potential reason is from the addition and modified mass distribution along the Invar structure due to installation of the cabling of HV and various sensors after the final positioning in the cryostat.

Effect taken into account in the readjustment of the horizontality and the nominal vertical position of CRP1 and CRP2 such that the  
**=> grids stay immersed by at least 4 mm in the liquid**



## Possible schedule for a 2-CRP production *(to replace the current 2 dummy CRPs)*

- 2020:
  - LEM prototyping and tests at CEA/Irfu, tests in CB at CERN.
  - LEM & anode final design.
  - CRP prototyping and tests: guard ring, resistive combs.
  - CRP final design.
- 2021:
  - Early 2021: start production of 1<sup>st</sup> CRP.
  - Mid-2021: tests in CB at CERN and start production of 2<sup>nd</sup> CRP.
- 2022:
  - Test of 2<sup>nd</sup> CRP in CB at CERN.
  - Integration in cryostat.

ProtoDUNE Project planning at LAPP for New CRP structure, tests and installation

7/01/2020

✎	✎ ProtoDUNE DP Upgrade	914,63	04/03/2019	06/03/2023	
✎	Premiers Résultats ProtoDUNE	246,75	04/03/2019	31/03/2020	
✎	Rédaction du TDR	55,88	05/03/2019	31/05/2019	
✎	Debriefing design & prod ProtoDUNE DP	246,75	04/03/2019	31/03/2020	
✎	✎ Etudes et essais	115,72	01/09/2019	04/03/2020	
✎	Modélisations thermiques intérieur ProtoDUNE	30,63	07/10/2019	22/11/2019	
✎	Modélisation de la grille incluant la force	66,5	18/11/2019	02/03/2020	
✎	Contraction thermique du fil	116,59	01/09/2019	04/03/2020	
✎	✎ Design CRP Upgrade	213,5	01/08/2019	07/07/2020	
✎	CAO Globale des CRPs	211,75	01/08/2019	07/07/2020	
✎	Optimisation EF du cadre invar	133,88	23/09/2019	22/04/2020	
✎	Simplification de la géométrie du G10	140,88	18/11/2019	29/06/2020	
✎	✎ Revue des systèmes de découplage	140,88	18/11/2019	29/06/2020	
✎	Revue design des systèmes de découplage	140,88	18/11/2019	29/06/2020	
✎	Tests de fiabilisation	96,25	27/01/2020	26/06/2020	
✎	Revue des peignes	140	18/11/2019	26/06/2020	
✎	Revue Grille d'extraction (plaquettes, fixations,	140,88	18/11/2019	29/06/2020	
✎	Revue fixation de l'instrument	140	18/11/2019	26/06/2020	
✎	Revue suspension/ancrages	140,88	18/11/2019	29/06/2020	
✎	Investigations procédures de métrologie et réglages	140,88	18/11/2019	29/06/2020	
✎	Design électronique (grille, peignes, plaquettes, LEM	140	18/11/2019	26/06/2020	
✎	Design faux LEMs – Anodes pour test structure	3	30/06/2020	03/07/2020	23
✎	Création/modifications système de tressage Grille pour Upgrade	149,63	01/10/2019	27/05/2020	
✎	Modifications boîte de transport	175	06/01/2020	09/10/2020	

✎	✎ Commande/production sous-traitance	431,88	06/01/2020	25/11/2021	
✎	Cadres Invar	160	23/04/2020	04/01/2021	22
✎	Cadres G10	120	08/07/2020	15/01/2021	20
✎	Visserie	20	08/07/2020	07/08/2020	20
✎	Pièces Méca usinées	60	08/07/2020	12/10/2020	20
✎	Plaquettes grille	60	30/06/2020	02/10/2020	34,28,32
✎	Fil de grille – Déjà dispo	0	29/06/2020	29/06/2020	34,28
✎	Peignes	30	30/06/2020	17/08/2020	28
✎	Pièces Elcom boîte transport	20	12/10/2020	11/11/2020	35
✎	✎ CEA LEMs–Anodes	431,88	06/01/2020	25/11/2021	
✎	Conception / Tests à l'IRF	231,88	06/01/2020	08/01/2021	
✎	Production LEMs CRP1	100	11/01/2021	18/06/2021	47
✎	Production LEMs CRP2	100	18/06/2021	25/11/2021	48
✎	Fausses anodes de test méca	30	03/07/2020	20/08/2020	23,33
✎	✎ Test Planéité Structure CRP	96,5	11/11/2020	15/04/2021	
✎	Préparation cadres invar	2	04/01/2021	07/01/2021	38
✎	Préparation cadres G10	4	15/01/2021	21/01/2021	39
✎	Préparation boîtes de transport / Structures de	5	11/11/2020	19/11/2020	45
✎	Métrologie G10 – Préparation banc de tressage	4	21/01/2021	28/01/2021	54
✎	Installation faux LEM/Anodes	4	21/01/2021	28/01/2021	50,53,54,55
✎	Tressage grille de test	10	28/01/2021	12/02/2021	56
✎	Installation grille de test	2	12/02/2021	16/02/2021	58
✎	Installation instrumentation pour masse	2	17/02/2021	19/02/2021	59
✎	✎ Comportement au froid de la structure test	34	19/02/2021	15/04/2021	
✎	Paquetage / Transport	2	19/02/2021	23/02/2021	60
✎	Tests ColdBox	30	23/02/2021	12/04/2021	62
✎	Paquetage / Transport	2	12/04/2021	15/04/2021	63

✎	✎ Jalons	552,38	01/10/2019	03/03/2022	
✎	CERN : Validation Phase II upgrade ProtoDUNE-DP	0	01/10/2019	01/10/2019	
✎	Fin de conception CRP Upgrade	0	02/06/2020	02/06/2020	20
✎	Fin de prise de données ProtoDUNE-DP	0	01/08/2020	01/08/2020	
✎	Cryostat disponible pour installation des CRP Upgrade	0	01/06/2021	01/06/2021	
✎	Fin d'installation des CRP Upgrade	0	03/03/2022	03/03/2022	79,97
✎	✎ DUNE DP Far Detector	1370,2	01/01/2020	31/12/2025	
✎	Conception Mécatronique Suspensions CRPs DUNE	230,13	01/01/2020	01/01/2021	
✎	Conception des outillages de production DUNE	364	01/05/2020	03/12/2021	
✎	Mise en place des sites de production DUNE	456,75	01/01/2021	02/01/2023	
✎	Construction des CRPs et suspensions DUNE	457,63	01/12/2022	02/12/2024	
✎	Installation DUNE dans le Cryostat	228,38	01/01/2025	31/12/2025	

✎	✎ Production CRP Upgrade #1	74,38	15/04/2021	12/08/2021	61
✎	Démontage structure test fro	1	15/04/2021	16/04/2021	64
✎	Tressage grille	20	16/04/2021	19/05/2021	42,43,34,28,51
✎	Installation LEMs – Anodes	4	18/06/2021	24/06/2021	67,48
✎	Installation grille	2	24/06/2021	29/06/2021	68,67,47,69
✎	Installation instrumentation et tests électriques	5	29/06/2021	06/07/2021	70
✎	Fermeture Boîte	2	06/07/2021	09/07/2021	71
✎	✎ Test au froid	21	09/07/2021	12/08/2021	
✎	Transport	1	09/07/2021	12/07/2021	72,64
✎	Préparation / Tests air	4	12/07/2021	16/07/2021	74
✎	Test au froid	15	16/07/2021	10/08/2021	75
✎	Paquetage / Transport	1	11/08/2021	12/08/2021	76
✎	✎ Installation CRP Upgrade #1	10	12/08/2021	27/08/2021	66
✎	Installation ProtoDUNE Upgrac	10	12/08/2021	27/08/2021	106,35
✎	✎ Production CRP Upgrade #2	107	27/08/2021	15/02/2022	52;78
✎	Préparation boîtes de transport / Structures de	5	27/08/2021	06/09/2021	35
✎	Préparation cadres invar	5	27/08/2021	06/09/2021	38
✎	Préparation cadres G10	8	27/08/2021	09/09/2021	39
✎	Installation LEMs – Anodes – Cablage	8	25/11/2021	08/12/2021	84,49
✎	Métrologie G10 – Préparation banc de tressage	2	08/12/2021	10/12/2021	84,85
✎	Tressage grille	10	13/12/2021	28/12/2021	86,42,43,34,21
✎	Installation grille	3	28/12/2021	31/12/2021	87,85
✎	Installation instrumentation et tests électriques	5	31/12/2021	10/01/2022	88
✎	Fermeture Boîte	2	10/01/2022	12/01/2022	89
✎	✎ Test au froid	21	12/01/2022	15/02/2022	90;77
✎	Transport	1	12/01/2022	13/01/2022	90
✎	Préparation / Tests air	4	14/01/2022	20/01/2022	92
✎	Test au froid	15	20/01/2022	14/02/2022	93
✎	Paquetage / Transport	1	14/02/2022	15/02/2022	94
✎	✎ Installation CRP Upgrade #2	10	15/02/2022	03/03/2022	95
✎	Installation ProtoDUNE Upgrac	10	15/02/2022	03/03/2022	106,35
✎	✎ Fin d'installation – Prise de données – Validation ProtoDUNE DP Upgrade	229,25	03/03/2022	06/03/2023	
✎	Fin d'installation – Prise de données – Validation ProtoDUNE DP Upgrade	229,25	03/03/2022	06/03/2023	79,97